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Review Article

Energy Efficient Approach in Wireless Sensor Network for Surveillance: A Review Analysis

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Abstract

Over recent years there is a huge growth in the area of wireless networks due to its efficient design. The word sensor is defined as component which handles & monitor different kinds of inputs from different sources such as physical and environmental conditions like pressure, heat, light, sound and vibrations etc. The output produced by the sensor will be electrical in nature and this electrical signal is further applied to various controllers for other functions. A Wireless Sensor Network is basically a form of ad-hoc network which consists of thousands of tiny sensor nodes. These wireless networks are deployed where the wired network implementation is difficult or impossible. These nodes are further distributed over a wide area such as hilly areas, forests, deserts, ocean etc. and these tiny sensors communicate or exchange data with each other by using radio signals. The WSN utilizes various communication protocols like Bluetooth, Wi-Fi, Zigbee and Ultra Wide Band techniques. Every protocol has its own speed and depending upon the distance between them, there are various problems which network can face like battery failure, effective coverage area, and effective energy utilization or node failure. In this paper, the several different methods to build energy efficient network, methods to improve the lifetime of a network, method for detection and correction of node failure and in the last the important applications are discussed.

Keywords: wireless networks, word sensor, electrical signal, Ultra Wide Band techniques.

1. INTRODUCTION

The sensor network has one of the key advantages that they are capable of eliminating the gap between the physical and logical world as they gather the information from physical world and communicate it to the powerful logical devices that are able to effectively process it. A sensor node performs three important functions: Sensing, Computing, and Communication. The sensing unit consists of a sensor which senses the activities in its surrounding. The sensor is driven by a power unit. The power unit is common to all the three sections of node network. The computing section is accompanied by the protocols that enable a disciplined working of the entire system. The last section of the architecture of the sensor node is responsible for the communication. It is usually a wireless network like Bluetooth, ZigBee etc.

Depending on the requirements of data-rate and communication range, a suitable module for the wireless communication can be selected. Thus, if we talk about the ability of the technology, it can lead to a reduced need for the human intervention or the interference for the information gathering in the military and civilian applications. Since human intervention is not possible in some specific areas so designing a network which is energy efficient and robust in nature is a major concern.

In the field of military surveillance, the sensor nodes are released from UAV i.e. Unmanned Air Vehicles (e.g. helicopter).Due to the random distribution of nodes from the air vehicle, the nodes get scattered i.e. more nodes will fall in one area while fewer nodes fall in some other area. Sensor nodes have limited energy, usually supplied by a battery. In view of the limited battery life, it is essential to make these nodes energy efficient.

2. Problem overview and challenges

The Wireless Sensor Network is one of the upcoming technologies in the field of wireless communication. There is a very little real-time development for the extent of this technology due to the following reasons: placement of node is a basic building block of a WSN, stated in and the cost of manufacturing is very high. Also, placing a node in remote areas of application is not an easy job and requires a considerable investment in terms of money, manpower, and machine-power. Since they are battery powered, there is no guarantee that node will last for a very long time and continuously sense the phenomenon in their surroundings. Moreover, if there is any damage in the network then the human intervention is practically not possible to remove or repair them. The sensor nodes are deployed in large numbers in remote areas. All these nodes are dependent on each other for the complete success of the network established by them. Even if a single node is faulty or if some problem is there, then the entire network fails. Hence, fault detection, fault tolerance, and the sensor node failure are important to be considered in the design of any WSN. The problem of faulty nodes or failure-prone nodes certainly affects the performance of a WSN.

Chaitanya Maamuni [1] discussed about sensor node failure that how it affects the coverage life of WSN. First of all the question arises when to call a node "faulty node" .So a node is said to be faulty when the data sent by a node to the base station is incorrect. Further faulty nodes can be classified in two types:
1. Permanent faulty nodes
2. Static faulty nodes

The permanent faulty nodes are the nodes in which the faults are present and they cannot be repaired, ultimately needs to be replaced for the proper functioning of the network. Whereas, static faulty nodes can be corrected. The other way of the classification of sensor nodes is software and hardware faults. The software faults are the faults in the software of the system i.e. the programming, the hardware is completely fine, due to improper functioning of the software, these nodes transmit wrong data to the system. In Hardware Faults, the fault is in the node, software part is totally fine, in this case we have to replace the node. The Fault Detection is a mechanism to find out the feasible faults in a working node and recover the node from that fault with the minimum utilization of energy sources and lesser time by using an algorithm method which is simple and easier to implement in the harsh ad-hoc networking scenarios.

Sensor node failure can also be classified in two types: Single node failure and multiple node failure. If in a cluster, all nodes are working and there is fault in only one node, remaining nodes are working. In multiple node failure, groups of nodes are not working.

C. V. Mahamuni *et al*., describes a military surveillance system based on WSN, where the nodes are randomly distributed in the sensor field for such applications because of which the density of nodes in some parts of the area to be monitored will be relatively more and in other areas might be very less. Another problem is the physical access to the sensor nodes in these areas is extremely challenging, so the human intervention is not easy. Thus, the replacement of nodes or recharging their batteries is practically impossible. Thus, it becomes necessary that the nodes deployed in a field should be utilized properly without wasting the power associated with them to achieve an energy efficient network performance.

3. Proposed Techniques

C. V. Mahamuni [1] discussed the concept of bathtub curve to check the probability of failure of sensor node. The bathtub curve is divided into three sections: decreasing failure rate, constant failure rate, and the last part refers to increasing failure rate. Initially, the rate of the failure is maximum; it decreases slowly to a constant value and after some time, it again starts increasing and reaches to its maximum value. This can be used to model the failure of the sensor nodes and optimize their schedule. The optimization of node-schedule incorporating the fault-tolerant nodes or the failure-prone nodes is based on Total Trip Time (TTT) and Received Signal Strength (RSS) [3]. One cannot completely eliminate the effect of failure on sensor nodes but it can be controlled to a certain extent by using TTT and RSS methodology .The total trip time calculated when the nodes undergo a communication with each other is obtained and then the average value of the same is found out. If the Total Trip Time (TTT) of any node is less the calculated average, then it is likely to be a faulty node. In the RSS-based method, one node is taken as the reference node and RSS of the test node is obtained by keeping both the nodes at the same distance from a common communicating node with the two, the lesser RSS than the theoretically expected and the RSS appearing at the reference node, one can declare that node as likely to be faulty [3]. The above techniques are not apt or suitable for the real-time WSN scenarios as the TTT and RSS of every individual node cannot be found out. The energy usage forms major constraints in the development of WSN. The energy consumption of sensor nodes is divided into following parts: the energy required by the transducer, energy for microprocessor computation and communication amongst the deployed nodes. Each of the bit to be transmitted utilizes energy same as needed to execute 800-1000 instructions. Thus, communication is much costlier than computation in a real sense.

Navreeginder Kaur *et al*., [4] presents basic routing protocols. Routing Protocols can be categorized into proactive, Reactive and Hybrid on the basis of type of target applications and Mode of functioning. Proactive Protocol is LEACH (Low Energy Adaptive

Clustering Hierarchy) is a MAC protocol based on TDMA technique. It is combined with general routing protocol and clustering in wireless sensor networks. The purpose of LEACH is to improve the life time of wireless sensor networks by increasing their energy efficiency. In Reactive Protocol, the nodes immediately react if the sensed attribute undergoes sudden changes beyond some threshold value, which is predefined. Threshold sensitive Energy Efficient sensor Network (TEEN) is used where there is a need to instantaneously transmit critical data to the user. Hybrid protocols are the combination of these two proactive and reactive protocols. Their function is to calculate all routers present and then improvisation is done during routing. Adaptive Periodic TEEN (APTEEN) is considered as an instance of Hybrid Protocols as it maintains three different types of queries: First one is one time, in which a view of the whole network is taken in the form of snapshot, second is historical in which analysis of past data values is done and third is persistent in which for a particular period of time and event is monitored [4].

Patnaik Nishan and KTV Reddy [5] present, comparison of various energy efficiency schemes LEACH, TEEN and SEP (Stability Election protocol). The clustering plays an important role in sensor network environment when the routing of data is considered. The randomly deployed sensors will form small groups called as clusters and a node will be appointed as a cluster head, all node send their transmission to the head node and it will be then forwarded to the base station. If each node has equal possibility to become a cluster head, then the total area will be effectively covered for longer time span. This is the basic concept of LEACH (Low Energy Adaptive Clustering Hierarchy) protocol because of which it can be used in routing as well as coverage schemes.

A SEP (Stability Election Protocol) which is a heterogeneous protocol to stretch the time before the first node actually dies. The probability of the node to become cluster head is weighted depending upon the residual energy of that node. The SEP protocol used for the sensor nodes will increase the stability of the network. A TEEN (Threshold Sensitive Energy Efficient Network) protocol which is the protocol developed for reactive networks and used in temperature sensing application that divides the sensor nodes twice for grouping cluster in order to detect the instantaneous changes in the sensed attributes. Pattnaik Nishan *et al.*, [5] highlights, the comparison of the results obtained for average energy of the nodes for all the three protocols, and the average energy of the node drops down to a very less value with increasing number of rounds in LEACH protocol to a very lesser value. The average life of node sharply declines in the next case which shows the requirement of enhancement in the life of node by increasing its energy efficiency as well as stability of the network i.e. sustaining energy with increasing rounds in simulation uniformly.

The SEP protocol performance gives best performance in the terms of average energy of node. The residual levels of energy for a node when it becomes active in sensing and transmitting at its random time till the current time plays an important role in development of any energy efficiency algorithm in sensor networks.

The Protocol performances in terms of node average normalised energy and number of dead nodes are explained graphically [5], where one can clearly see the enhancement in performance efficiency.

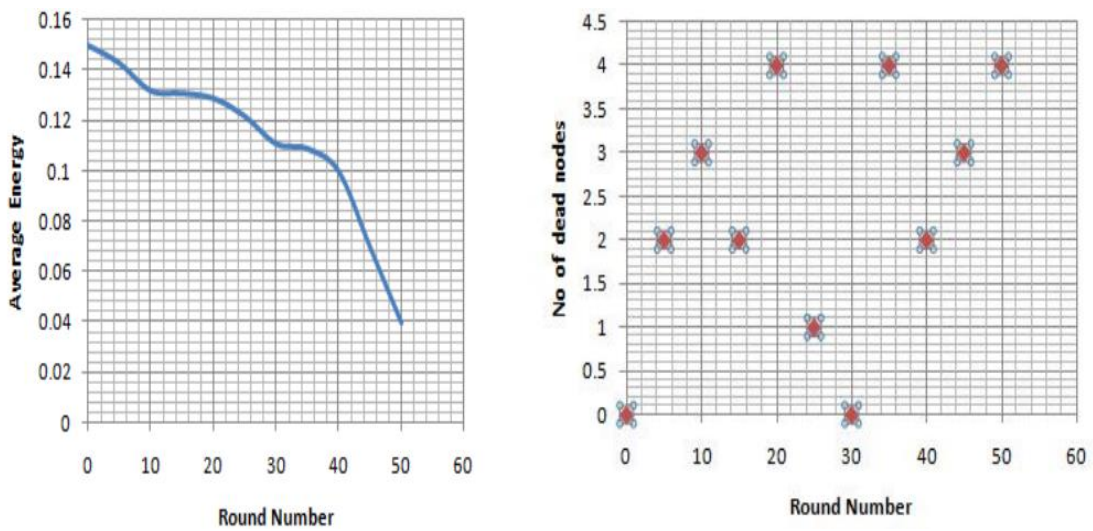

Fig 1: Average energy of node and number of dead nodes for LEACH protocol [5]

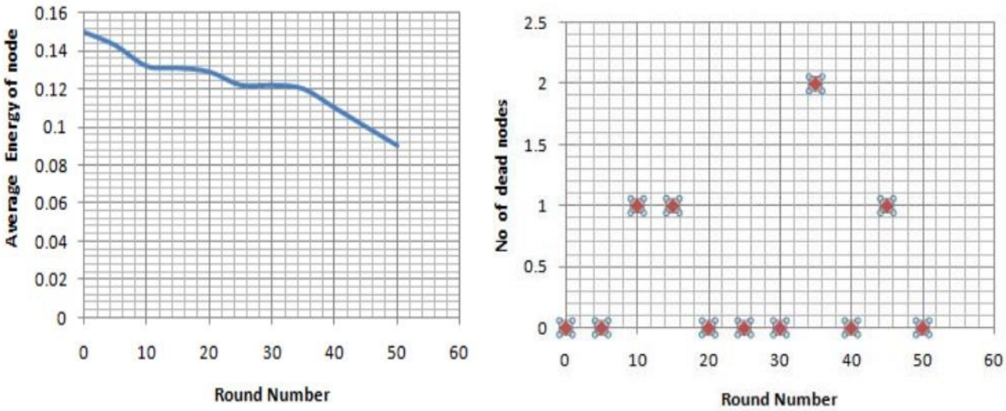

Fig 2: Average energy of node and number of dead nodes for TEEN protocol [5]

The results of simulation show that average energy of node in TEEN protocol decreases when the round number increases. The fifty rounds indicate the total simulation time being around 1500 seconds. However, the protocol results are better than the results obtained for LEACH protocol in both the cases i.e. average energy of node and the number of dead nodes.

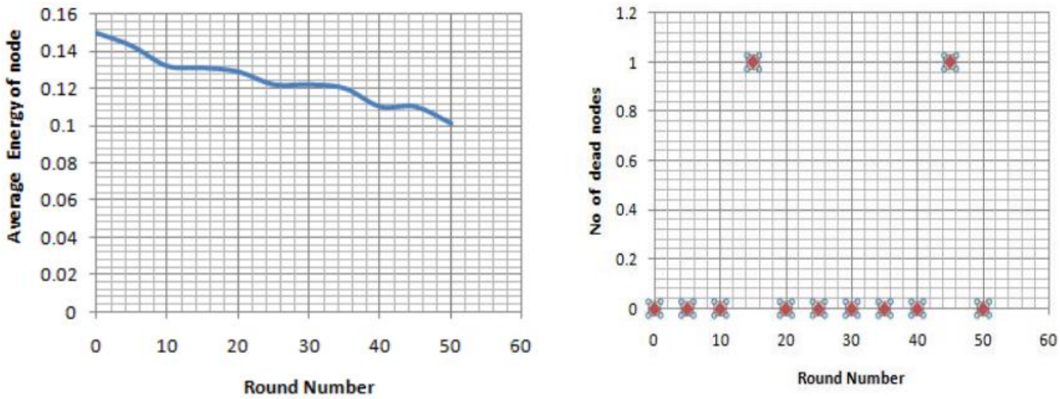

Fig 3: Average energy of node and no of dead node for SEP protocol [5]

From these three Figures, it is clearly predicted that sep is better than both LEACH and TEEN protocol. Benzerbadj Ali *et al.*, [6] presented energy efficient approach to the surveillance application. In this paper,the authors have considered two kinds of nodes, boundary and non boundary nodes for the simulation analysis. The Boundary nodes have mainly the role of sentry while non boundary nodes act only as relay. When an event is detected by sentry node, an alert is sent to the sink node through relay nodes in order to take the suitable decision. This system take place in two phases, initialization and surveillance. During initialization phase, where all deployed nodes are supposed to be in active mode, neighbourhood discovery is launched. The latter is followed by boundary nodes identification. Once the identification of boundary nodes is finished, non boundary nodes are put in the sleep mode. The Surveillance phase starts immediately after that Simulation results are seen, in terms of energy consumption and percentage of alerts delivered which prove to be encouraging. Indeed, even when all nodes are active, a loss of alerts due to interference effects can be noticed.

Avinash and Vijay Raisinghani [7] used the concept of Random Backoff Sleep Protocol for Energy efficient coverage area and the concept is the probability of neighbouring nodes becoming active is inversely related to the remaining energy level of the current active node. The Random Backoff Sleep Protocol (RBSP) is a probe based protocol which utilizes the information about residual energy level in the active node. So, when an active node has high residual energy, the probability of a neighbouring node turning on is low. Similarly, when an active node has low residual energy, the probability of a neighbour node turning on is high. This will help in balancing the energy consumption among the nodes. Due to this, one can expect the network lifetime to increase substantially.

In the protocol applied for implementation, each node has 10 energy levels depending on its residual energy. The energy level i and the sleeping window SWi, corresponding to the energy level of a node, are shown in the equation below [4].

$$i = ceil(\frac{b\%}{10})$$
$$SW_i = 2^i to 2^{i-1}$$
………. (1)

Where, b is the battery level of node in percentage. Each node initially starts from energy level i = 10 where its sleeping window is SWi=10 = 2^{10}to2^{10-1}, i.e. (1024-512). When the active node consumes more than 10% of its initial energy, its energy level changes to i = 9 and its sleeping window size decreases to SW $_{i=9}$ = 2 ^{9}to2^{9-1}, i.e. (512-256). Similarly, if the active node consumes 20% of its initial energy, its energy level changes to i = 8 and its sleeping window size decreases to SW $_{i=8}$ = 2^8to2^{8-1} i.e. (256-128). In this way, the sleeping window size becomes smaller as the node consumes more power. The Backoff Sleep Time (BST) used by a node based on energy level i is given by [4]:

$$BST = Random(SW_i) * \frac{R_E}{I_E} * \eta$$
…………………. (2)

In CV Mahamuni *et al.*, [8] the information about the Optimal Backoff Sleep Time algorithm for effective sleep scheduling of sensor nodes is provided. It calculates the sleep time for probing node depending on the percentage of the battery left with active node within its coverage with multiple levels of binning after which the next wakeup is expected. In addition, the maximum allowable latency in the inter-node communication is also incorporated with which variant sleep profiles are obtained for different applications leading to a latency tuned network coverage.

Kuraparthi Tirumala Viswanatha, [9] and C. Vijay Kumar [10] have presented the optimal node scheduling based on optimal Backoff sleep and active node failure respectively. The main aim of the work is to achieve energy efficient coverage by increasing the coverage lifetime of the network. This has been accomplished by keeping a minimum number of nodes active in the sensor field and putting the remaining nodes in the sleep state. The important terms for Optimal Backoff sleep protocol are.

1. Active state
2. Probing state
3. Sleeping state
4. Dead state

A Node is said to be in active state if it works like a full functioning device, where the transducer will sense it's surrounding and the sensed information will be processed and transmitted to the desired location. All the functions including sensing, processing, transmitting & receiving i.e. communication will take place. A node is said to be in Probing state when the node which is active will continuously transmit some packets to check whether any other node is active within its coverage and if yes it will transit to sleep state. A node is said to be in Sleeping state when the transducer will sense the phenomenon but its output will not be processed and transmitted. Unless any active node interrupts, the wireless module will also not communicate. Hence, the power is saved.

A Node is said to be in Dead state: If the battery is fully drained or the external power supply is cutoff then the node will die. This state is called as dead state. The nodes deployed in the sensor field will be activated by a randomized timer. Once the nodes are active, they will continuously probe their environment to check if any other neighbour node is active within its coverage. If no, then the node itself will remain active otherwise it will decide its sleep time and transit to sleep state. The sleep time is computed based on the following equation:

Sleep Time = Rand (M – N) x (1-PNF)…………….. (3)

Where,
M: Statistical mean of life of a node observed at different number of runs in minutes
N: Life of active node at the time of probing in minutes
PNF: Probability of Node Failure (of active node)

The authors [8] have used bathtub curve to calculate the PNF value.

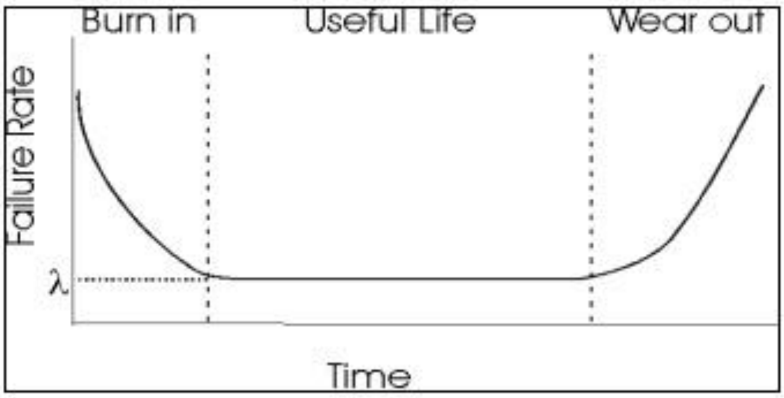

Fig 4: Bathtub curve [9]

All the randomly deployed nodes in the sensor field are activated by a randomized timer after which they will probe their surroundings to check whether there is any active node present within their range or not. If there is no node active, then the probing node will go into the sleep state and continue to be in that state till it fully times out i.e. undergoes the dead state. If there is any active node present within the range of the probing node, the Sleep Duration (SD) will be calculated based on the optimization criterion discussed earlier it will transit to the sleep-state. After SD is over, it will wake up and again go back to the probing state and, the process completes the loop till the dead state is finally reached. There are four states which every node goes through and those are the active states.

Fan Ye., F. Zhong *et al*., [10] presented PEAS, a robust energy-conserving protocol that can build long-lived, resilient sensor networks using a very large number of small sensors with short battery lifetime. PEAS extends the network lifetime by maintaining a necessary set of working nodes and turning off redundant ones. PEAS operations are based on individual node's observation of the local environment and do not require any node to maintain per neighbor node state. PEAS performance possesses a high degree of robustness in the presence of both node power depletions and unexpected failures.

Chaitanya Vijaykumar Mahamuni [11] proposed Optimal Backoff Sleep Time Protocol for improvement in network performance by increasing the coverage lifetime. An embedded hardware that resembles a mote has been developed for implementation of the protocol at the virtual level. The various parameters like the average life of node, the radio range of the protocol, the probing time, the probing frequency and the Coverage Lifetime (CL) were observed practically.

Mahamuni, Chaitanya Vijaykumar, and K. T. V. Reddy [12] the results of the software and hardware implementation of Optimal Node Scheduling Protocol (ONSP) based on a new algorithm that optimizes the node schedule based on the randomized sleep assignment and the probability of failure of active nodes within the range of a probing node. The evaluation based on the simulation carried out in MATLAB and the runtime assessment of the protocol for the performance enhancement of randomly deployed WSNs is presented in the paper.

Parul Tyagi, Surbhi Jain [13] In this paper, we analyze recent routing protocols for wireless sensor network and classify in three types of approaches according to network architecture in WSN. The three main categories on the basis of network structure: Flat, Hierarchical and location based routing protocols. We study tradeoff between energy and communication overhead savings in every routing protocols.

S. Indhumati and D. Venkatesan [14] By using maximum coverage sensor deployment problem, the Coverage achieved only for static nodes. In the proposed system, a Genetic Algorithm is used to deploy Sensor Nodes for the Maximum coverage within the area, where the sensors are of different types. In this work, first analyze the total coverage area the WSN, identify the types of Sensor nodes and Coverage sensing distance, and calculate the coverage sensing distance for the combination of all sensor types based on radius of each node. Improving the deployment of Dynamic nodes for achieving maximum coverage deployment by using Genetic Algorithm. As a result, we were implemented this work in Java. This will show the best performance in coverage and network lifetime.

A. Ali, YK, Jadoon *et al*., [15] his article outlines the military applications of wireless sensor networks (WSN). The combat activities in modern military operations are divided into different categories, which give the requirements and restrictions for wireless sensor networks. The type of sensor and its function can adjust and limit the use of WSN. A WSN military application's capacity depends on various factors, including capabilities of sensors, type of sensors, the architecture of wireless communications, its range, and appropriate data processing. We performed a categorization of WSN applications used in the military according to the strategic scenario and sensor type.

4. REVIEW ANALYSIS

Title of the Paper	Author	Technique Used	Result
Sensor Node Failure Affecting Coverage of WSNs: An Overview	C. V. Mahamuni	PNF, BATHTUB CURVE method	Detection of faulty nodes,sleep duration of nodes
A Robust Coverage based on Optimal Backoff Sleep Time in Wireless Sensor Networks	C.V. Mahamuni, K. T. Reddy	Optimal Backoff Sleep Time Protocol, BATHTUB CURVE	There is a 10.2% increase in the Coverage Lifetime (CL) of the network observed after implementation of the protocol.

The preservation of energy and strong energy performance of sensor hubs plays a significant function in building up any real-time application utilizing remote sensor network. In this paper, we discussed about different energy productive methodology for Wireless sensor organization. WSN is an advancing innovation that shows promising applications both for military and mass public. Other than these applications, vehicle identification and blockage control can be decreased.

Random Backoff sleep Protocol for energy efficent network coverage in wireless sensor network	Avinash More	RBSP Protocol	RBSP maintain adequate number of nodes active for longer period of time .aprrox.12.5% longer
Energy Efficient Approach for Surveillance Applications Based on Self Organized Wireless Sensor Networks	Ali Benzerbadja, B. Kecharb, A Bounceur `	GPS, Boundary and non Boundary technique of placement of node	Approach which minimizes energy consumption in order to extend WSN lifetime and insures an acceptable percentage of alert messages delivered.
A Military Surveillance System based on Wireless Sensor Networks with Extended Coverage Life	Mr.Chaitanya Vijaykumar Mahamuni	Effective coverage area and efficient protocol technique	The use of the optimal node scheduling based on the presence of an active node within range of its probing node and the likelihood of its failure for the energy efficient coverage of WSN's for the military surveillance
A Review of Wireless Sensor Network with Its Applications	Navreetinder Kaur, Tarandeep Singh	Increasing efficiency by routing protocols	Various application of WSN and study of protocols
A Relative Study and Analysis of Various Energy Efficiency Schemes in Wireless Sensor Networks	Chaitanya Mahamuni, KTV Reddy, Nishan Patnaik,	Comparsion of routing Protocols, TEEN LEACH ,SEP	SEP is best among all three

The sensor hub malfunction is a basic issue in the distinctive situations of WSN like military zones, disaster relief operations and so forth where there is an irregular arrangement of sensor hubs from air vehicles. The different plans to accomplish energy proficiency in remote sensor organizations were considered and the relative investigation of their execution of them was made.

5. Conclusion & Impact of Study

Ubiquitous Communications through Wireless Sensor Network is a revolutionary concept which aims to provide pervasive, reliable communication and surveillance services wherever required. The energy efficient approach in wireless sensor networks has gained significant interest in academia and industry which continues to attract tremendous research efforts due to new opportunities in the field of wireless networks. This emerging technology is being developed for a wide range of key areas including wireless sensor networks, embedded systems, agent technologies, autonomic communication and above all wireless network information security.

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